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Original Research Article

Response of orange – Fleshed sweetpotato (*Ipomea batatas* (L) Lam) to ratoon cropping and nutrient management in Southern Nigeria

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Lack of sustainable seed system is a major constraint to sweetpotato production in Nigeria. Healthy vines are insufficient at the onset of the rains, after the dry season has desiccated the previous crop. To raise vines and alleviate this problem, this study evaluated the effects of ratoon cropping and nutrient management on orange-fleshed sweetpotato in the rainforest agro-ecology of South-southern Nigeria. The experiment was a split-plot arranged in a randomized complete block design with three replications. Results revealed that sweetpotato plant crop produced significantly more branches, higher leaf area index, dry matter of shoot and root and higher fresh shoot biomass than the first and second ratoon crops. Ratoon cropping did not significantly affect root yield in 2017. However, in 2018, the trends in root yield showed that the plant crop yielded highest followed by first ratoon and second ratoon. Application of a combination of 2.5t/ha poultry manure + 200kg/ha NPK significantly increased leaf area index, fresh shoot biomass and root yield. Production of seed for potato planting should prioritize the plant crop and for improved yields, producers should apply 2.5t/ha poultry manure + 200kg/ha NPK.

Keywords: Growth, nutrient management, orange-fleshed sweetpotato, ratoon cropping, root yield.

INTRODUCTION

Sweetpotato (*Ipomea batatas* (L) Lam) is an important root crop which has been grown in the subsistence agricultural system of Nigeria since the 17th century (Nwinyi, 1987). It is a major source of carbohydrate and its yield in 3 – 5 months compares with those of yam, cocoyam and cassava, which mature in 8 – 18 months. Most sweetpotato cultivars in Nigeria have white-fleshed or cream-fleshed roots, but those with orange-flesh, are now being promoted because of their high beta carotene content, a precursor of vitamin A (Sreekanth, 2008). The strategy of increasing orange-fleshed sweetpotato consumption helps to improve nutrition and alleviate vitamin A deficiency, which causes night blindness. Sweetpotato has also been reported to have the potential to reduce the incidence of diseases such as colon cancer, diabetes, heart diseases and disturbances (Udoh et al., 2005; Palmer, 1982).

Despite the fact that the crop is adapted to a broad range of agro-ecological conditions as well as low input agriculture, its productivity in Nigeria is low, at 3–9t/ha in farmers' fields (BNARDA, 2007). Law – Ogbomo et al. (2014) attributed the low productivity of the crop to poor management practices including recurrent use of unclean vines and poor soil fertility. Farmers usually use vine cuttings from previous crops or volunteer plants as

Table 1. Agrometeorological data of the experimental site for 2017 and 2018

Month	Rainfall (mm)	
	2017	**2018**
January	30.8	33.4
February	71.5	75.5
March	150.6	153.8
April	191.0	193.1
May	260.0	260.4
June	291.3	392.8
July	353.8	353.5
August	300.0	312.0
September	380.8	395.9
October	318.5	325.1
November	140.1	137.4
December	30.5	29.8
Total	2518.9	2662.7

Source: University of Uyo, Nigeria weather Station

planting materials and this results in the accumulation of pathogens and low yields (Akpaninyang et al., 2022).

One way of providing good vines early in the cropping season, is the cultivation of crop regrowth or ratoon cropping, but this option has not been fully explored in sweetpotato production in Nigeria. In other crops such as sugarcane, castor, and waterleaf, the effects of ratoon cropping have been reported with varied results (Ugbaja et al., 1995; Okpara et al., 2014; Efretuei et al., 2022; Ahmed et al., 2012; An et al., 2003; Gonzales et al., 2003).

Like other root and tuber crops, sweetpotato responds well to soil nutrient levels, especially nitrogen and potassium (Thomas et al., 2023, Akpaninyang et al., 2013). Most resource – poor farmers, however, can hardly afford the high cost of inorganic fertilizers (Udounang et al., 2022a, Akpaninyang et al., 2015). There is therefore, the need to look at alternatives such as manure or combined use of fertilizer and manure in addressing soil fertility problems and to reduce production costs. Manure is readily available to many farmers in some parts of Nigeria and can be used to improve soil fertility (Akpaninyang et al., 2013). The objective of this study was to determine the response of orange – fleshed sweetpotato to ratoon cropping and nutrient management in southern Nigeria.

MATERIALS AND METHODS

The study was conducted during the 2017 and 2018 cropping seasons at the research farm of Akwa Ibom State University, Obio Akpa, Uyo, South-south Nigeria. Obio Akpa lies at latitude $4^{0}30^{1}$N and $5°30^{1}$N and longitude $7^{0}30^{1}$E and $8^{0}00^{1}$E. The soil is a loamy sand ultisol. Soil analysis before planting showed a range of 83.6 – 85.7% sand, 8.6 – 8.7% silt, 5.7 – 7.7% clay, 0.11 – 0.12% N, 5.16 – 5.18 mg P/kg soil and 0.14 – 0.15 Cmol K/kg soil. Rainfall data of the experimental site are presented in Table 1.

The experiment involved raising vines in the nursery to supply ratooned planting materials at regular intervals for the field planting. The nursery beds were raised 20cm above ground level after the incorporation of 5t/ha of well decomposed poultry manure. The nursery beds measured 1m x 4m ($4m^2$). There were three beds which yielded vines for the plant and ratoon crops in the field. After the establishment of the first bed, the second bed followed 4 weeks after the first bed while the third bed was prepared 4 weeks after the second bed.

Sweetpotato vine cuttings of 20cm length were planted at a spacing of 20cm x 10cm on the beds, with at least two nodes buried in the soil. 50 vine cuttings were planted per m^2, giving 200 vine cuttings for $4m^2$ nursery bed. The beds were watered regularly until the rains became steady. Sweetpotato plants in the first bed were cut at 8 and 12 weeks after planting (WAP). Plants in the second bed were cut at 8 WAP while those in the third bed served as control and were not cut. All the cut vines were discarded and the subsequent re-growths taken to the field for planting after 4 weeks of growth. Weeds were regularly removed by hand. The beds and cutting regimes provided different ratoons. The first, second and third beds provided the second ratoon, first ratoon and plant crops respectively. The vines of the re-growths were ready for transplanting to field plots at 4 weeks. Vines from the third bed (control) were transplanted to field plots at 8 weeks.

The treatments were arranged as split plot in randomized complete block design (RCBD) with three replications. The main plot treatments were four fertilizer combinations (0 (control), 400kg/ha NPK (15:15:15), 5t/ha poultry manure (PM), and 2.5t/ha PM + 200kg/ha NPK, while the sub-plot treatments were the ratoons (first ratoon, second ratoon, and plant crop). Each plot measured 3m x 3m ($9m^2$). Some chemical characteristics of the poultry manure were pH

Table 2. Effect of ratoon cropping on leaf area index of orange – fleshed sweetpotato at different sampling intervals in 2017 and 2018

	Weeks after planting		
Ratoon	8	10	12
2017			
First ratoon	0.69	0.82	0.85
Second ratoon	0.83	0.78	0.86
Plant crop	0.56	0.85	0.84
Mean	0.69	0.81	0.85
LSD (0.05)	0.13	NS	NS
2018			
First ratoon	1.27	1.29	1.37
Second ratoon	1.18	1.08	1.30
Plant crop	1.36	1.30	1.38
Mean	1.27	1.22	1.35
LSD (0.05)	0.09	0.12	0.05

Table 3. Effect of fertilizer combination on leaf area index of orange – fleshed sweetpotato at different sampling intervals in 2017 and 2018

	Weeks after planting		
Fertilizer combination	8	10	12
2017			
0	0.47	0.73	0.78
400kg/ha NPK	0.70	0.90	0.86
2.5t/ha PM + 200kg/ha NPK	0.83	0.78	0.87
5t/ha PM	0.77	0.84	0.90
Mean	0.69	0.81	0.85
LSD (0.05)	0.10	NS	0.06
2018			
0	1.27	1.18	1.34
400kg/ha NPK	1.20	1.22	1.31
2.5t/ha PM + 200kg/ha NPK	1.40	1.32	1.39
5t/ha PM	1.22	1.17	1.38
Mean	1.27	1.22	1.35
LSD (0.05)	0.12	0.10	NS

8.15, 2.03% N, 4.15% P, and 3.2% K. Sweetpotato vine cuttings of 20cm length were planted 30cm apart along the crest of ridges. The plants were spaced at 1m x 0.3m to maintain a plant population of 33,333 plants/ha. Supply of vacant stand was done at 2 WAP. Weeding was done at 7 and 12 weeks after planting. The poultry manure rates were applied into appropriate plots immediately after ridging and before planting. NPK 15:15:15 fertilizer was applied at 8 weeks after planting to the appropriate plots. The method of application used was ring method. Harvesting was done at 18 weeks after planting.

Agronomic data were collected on leaf area index, shoot dry matter (g/plant), fresh shoot biomass (t/ha), number of storage roots/plant, storage root weight (kg/plant) and storage root yield (t/ha). The data collected were subjected to analysis of variance and the means that differed significantly were separated using Fisher's least significant difference test at 5% probability level using GenStat (2007) statistical package.

RESULTS

The monthly rainfall was low early in the season (April to May) than later (June to October) (Table 1). Total annual rainfall was higher in 2018 and the first and second peaks of rainfall were in July and September in 2017 and in June and September in 2018.

At sampling taken at 8 WAP, leaf area index was significantly higher in the second ratoon than in the first ratoon and plant crops in 2017 (Table 2). Ratoon cropping did not influence leaf area index at 10 and 12 WAP. In contrast, in 2018, the plant crop had markedly higher leaf area index than the second ratoon crop at all sampling dates. The first ratoon and plant crop maintained similar leaf area index across the sampling periods. Application of NPK fertilizer or manure alone or combining NPK fertilizer and manure in 2017 resulted in significantly higher leaf area index than the no fertilizer control at 8 and 12 WAP (Table 3). At 8 and 10 WAP in 2018, combining inorganic

Table 4. Effect of ratoon cropping and fertilizer combination on fresh shoot biomass (t/ha) of orange – fleshed sweetpotato in 2017 and 2018

Fertilizer combination	Ratoon crops			Mean
	First	Second	Plant	
2017				
0	7.4	7.0	7.0	7.2
400kg NPK	6.8	8.8	10.3	8.6
5t/ha poultry manure	10.8	11.4	11.1	11.1
2.5t/ha PM + 200kg/ha NPK	13.3	10.1	13.9	12.4
Mean	9.6	9.3	10.6	
2018				
0	14.2	13.2	15.5	14.3
400kg NPK	14.9	12.9	17.4	15.1
5t/ha poultry manure	16.0	14.7	16.9	15.9
2.5t/ha PM + 200kg/ha NPK	16.0	14.2	17.3	15.9
Mean	15.3	13.8	16.8	

	2017	2018
LSD (0.05) for ratoon (R) means =	NS	1.15
LSD (0.05) for fertilizer (F) means =	2.83	1.03
LSD (0.05) for R x F means =	NS	NS

Table 5. Effect of ratoon cropping and fertilizer combination on number of storage roots/plant of orange – fleshed sweetpotato in 2017 and 2018

Fertilizer combination	Ratoon crops			Mean
	First	Second	Plant	
2017				
0	1.35	1.13	1.18	1.22
400kg NPK	1.28	1.39	1.22	1.30
5t/ha poultry manure	1.37	1.57	1.47	1.47
2.5t/ha PM + 200kg/ha NPK	1.55	2.00	1.40	1.65
Mean	1.39	1.52	1.32	
2018				
0	1.15	1.13	1.38	1.22
400kg NPK	1.25	1.08	1.40	1.24
5t/ha poultry manure	1.31	1.10	1.37	1.26
2.5t/ha PM + 200kg/ha NPK	1.35	1.19	1.35	1.30
Mean	1.27	1.13	1.38	

	2017	2018
LSD (0.05) for ratoon (R) means =	NS	0.09
LSD (0.05) for fertilizer (F) means =	0.13	NS
LSD (0.05) for R x F means =	NS	NS

NPK and manure resulted in higher leaf area index compared to other treatments. Leaf area index increased gradually up to 12 WAP in 2017, but dropped slightly in 2018 at 10 WAP, and thereafter rose to peak value at 12 WAP.

Fresh shoot biomass of the orange-fleshed sweetpotato was not affected by ratoon cropping in 2017, but in 2018, the plant and first ratoon crops had comparable shoot yields, which were significantly higher than that of the second ratoon crop (Table 4). In 2017, a combination of 2.5t/ha poultry manure + 200kg NPK fertilizer or 5t/ha poultry manure alone increased fresh shoot biomass significantly than application of NPK fertilizer alone and the no fertilizer control. Similarly, in 2018, application of 2.5 t/ha poultry manure + 200kg NPK or 5t/ha poultry manure increased shoot biomass over the control. Interactions were not significant.

The number of storage roots per plant was unaffected by ratoon cropping in 2017 (Table 5). In 2018, however, the plant crop significantly enhanced the number of tuberous

Table 6. Effect of ratoon cropping and fertilizer combination on root weight (kg/plant) of orange – fleshed sweetpotato in 2017 and 2018

Fertilizer combination	Ratoon crops			Mean
	First	Second	Plant	
2017				
0	0.21	0.26	0.21	0.23
400kg NPK	0.22	0,26	0.25	0.24
5t/ha poultry manure	0.31	0.28	0.29	0.29
2.5t/ha PM + 200kg/ha NPK	0.31	0.31	0.35	0.32
Mean	0.26	0.28	0.28	
2018				
0	0.14	0.10	0.14	0.13
400kg NPK	0.15	0.13	0.19	0.15
5t/ha poultry manure	0.16	0.12	0.19	0.15
2.5t/ha PM + 200kg/ha NPK	0.14	0.12	0.19	0.15
Mean	0.15	0.12	0.18	

	2017	2018
LSD (0.05) for ratoon (R) means =	NS	0.02
LSD (0.05) for fertilizer (F) means =	0.04	NS
LSD (0.05) for R x F means =	NS	NS

Table 7. Effect of ratoon cropping and fertilizer combination on storage root yield (t/ha) of orange – fleshed sweetpotato in 2017 and 2018

Fertilizer combination	Ratoon crops			Mean
	First	Second	Plant	
2017				
0	9.3	9.7	8.5	9.2
400kg NPK	10.0	13.3	9.2	10.8
5t/ha poultry manure	14.5	14.7	13.8	14.3
2.5t/ha PM + 200kg/ha NPK	16.0	20.9	16.9	17.9
Mean	12.4	14.6	12.1	
2018				
0	5.4	3.8	6.5	5.3
400kg NPK	6.1	4.6	8.7	6.5
5t/ha poultry manure	5.3	4.4	8.8	6.2
2.5t/ha PM + 200kg/ha NPK	6.3	4.9	8.5	6.5
Mean	5.8	4.4	8.1	

	2017	2018
LSD (0.05) for ratoon (R) means =	NS	0.90
LSD (0.05) for fertilizer (F) means =	2.36	0.86
LSD (0.05) for R x F means =	NS	NS

roots over first ratoon, which also had higher values than the second ratoon crop. Application of NPK fertilizer and poultry manure produced significantly the highest number of roots, followed by poultry manure alone while NPK fertilizer alone and the control had the lowest number of roots in 2017. In 2018, the number of roots was unaffected by application of NPK fertilizer or manure. The effect of interaction between ratoon cropping and fertilizer combination were not significant in both years on number of storage roots.

Ratoon cropping did not significantly affect the weight of storage roots in 2017 (Table 6). In 2018, the highest root weight was obtained in the plant crop, followed by the first ratoon while the lowest weight of roots occurred in the second ratoon crop. A combination of NPK fertilizer and manure or poultry manure alone significantly increased root weight over NPK fertilizer alone or the control in 2017. In 2018, fertilizer or manure application did not affect root weight. Ratoon cropping x fertilizer combination interaction effects were not significant on root weight in both years.

In 2017 cropping season, ratoon cropping had no effect on orange-fleshed sweetpotato root yield (Table 7). However, in 2018, the plant crop had significantly higher

storage root yield than the first ratoon, which also gave higher yield than the second ratoon crop. The plant crop which had the highest root yield in 2018, was higher than the values of the first and second ratoon crops by 40% and 84%, respectively. In 2017, combined application of 2.5t/ha poultry manure + 200kg NPK produced the highest root yield, followed by application of 5t/ha poultry manure while the application of 400kg NPK fertilizer and the control (0t/ha) had lowest yield. The trend was different in 2018, and application of inorganic NPK fertilizer or manure or a combination of fertilizer and manure gave similar yields which were significantly higher than the control (no fertilizer or manure). Interactions were not significant and between the years, storage root yield appeared much higher in 2017 than 2018.

DISCUSSION

Ratoon cropping reduced orange-fleshed sweetpotato fresh shoot biomass, due probably to loss of vigor in the ratoon crop. The apparent loss of vitality suggests that the plant may have entered the senescence phase which invariably affected its capacity to make use of environmental resources and assimilates. Bidwell (1979) reported that senescence, depending on the habit of growth of plants, occurs in different ways and could involve senescence of whole plant, progressive senescence of parts as the whole plant ages or sequential senescence of parts or tissues even when the plant as a whole is in a state of vigorous growth. In one out of two seasons, the plant crop had the highest shoot and root yields, followed by the first ratoon while the second ratoon crop had the least, showing a progressive decline in yields with ratoon cropping. Milthorpe and Moorby (1974) stated that progressive senescence in plants is accompanied by loss of chlorophyll, which reduces photosynthetic activity and yield. In the 2018 crop, leaf area index washigher in the plant crop, with a slight drop at 10 WAP, due probably to mutual shading and senescence or loss of lower leaves at this period. The higher leaf area index of the plant crop was associated with a high amount of radiation intercepted contributing to an increase in root yield. The leaf area index of a plant is an indicator of its photosynthetic capacity and translocation into tubers, which reflects in plant growth and vigour (Law-Ogbomo and Remison, 2007; Udounang et al., 2022b). In sugarcane, Okpara and Okocha (2001) and Glaz et al. (1989) found that yield of cane declined from the plant-cane through the first or second ratoon crop. On the contrary, Ugbaja et al. (1995) obtained higher number of capsules, higher seed weight and yield from the ratoon of castor oil plant, indicating varying yield responses to ratoon cropping by different crop species. In the present study, fresh shoot yield was on average higher in the plant crop than the first and second ratoon crops by 10% and 19% respectively in 2018. Similarly, storage root yield in the plant crop which gave the highest yield in 2018 was higher than those of the first and second ratoon crops by 40% and 84%, respectively.

Application of 2.5t/ha poultry manure + 200kg/ha NPK or 5t/ha poultry manure alone enhanced shoot biomass while application of NPK fertilizer alone did not increase this growth parameters in 2017. Udounang et al. (2022) reported that manures or organic inputs improve the use efficiency of inorganic fertilizers while Poultry manures like other organic manures have been shown to have long lasting effects on crops, due to slow mineralization and release of nutrients. On average, application of 2.5t/ha poultry manure + 200kg NPK gave comparable shoot yield as 5t/ha poultry manure alone but the highest storage root yield was obtained from a combination of 2.5t/ha poultry manure + 200kg NPK fertilizer. Akpaninyang et al. (2013) reported similar trend on sweetpotato. The higher yields with a mixture of NPK fertilizer and manure reflect the richer supply of nitrogen and potassium (Njoku et al., 2001) which are critical for crop performance.

Fresh shoot biomass was lower by 36% in 2017 compared to 2018; by contrast, root yield was higher by 115% in the former than the latter. This result was due probably to a combination of agronomic and weather factors. For example, planting date in this study was 24 June in 2017 and 5 May in 2018, with the former falling within the optimum planting time of late May to early July. According to Anioke (1999) this is the optimum season for root yield in sweetpotato in the environment at Umudike, south eastern Nigeria. Furthermore, weather data showed that 2018 recorded higher annual rainfall (2662.7mm) than 2017 (2518.9mm). Excess moisture has been shown to cause poor tuberous root development in sweetpotato (Abaka – White, 1992). The early planting and early heavy rainfall of the wetter 2018 may have encouraged excessive vine growth at the expense of root production. This is consistent with earlier reports in cowpea (Gyansa – Ameyaw and Doku, 1983; Afolabi, 1980) and African yambean (Okpara, 1999) which indicated that excessive leaf and stem production intensified intra – plant competition for assimilates to the disadvantage of developing pods. For the semi-erect, Umuspo 1 orange-fleshed sweetpotato variety, mean leaf area index was 0.69 – 0.85 in 2017 and 1.22 – 1.35 in 2018. Competition for light is often the limiting factor under such conditions of crop leafiness as was the situation in 2018, when the photosynthetic rate is decreased in shaded leaves, whereas the rate of respiration is increased (Mengel and Kirkby, 1987). As mutual shading is intensified, the net assimilation rate is decreased (Ekwere et al., 2023). Murata (1969) indicated that when shoot growth is greatly stimulated, it in turn decreased the translocation of carbohydrates to the root, thereby suppressing its growth.

Conclusion

Sweetpotato plant crop on average gave a higher shoot

biomass than the ratoon crops. This study showed that there is a possibility of compromising root yield in the following ratoon crop . In view of this, it may not be advisable to go beyond the first ratoon crop when raising vines for root yield in order not to jeopardize yields. A balanced fertilization using a combination of 2.5t/ha poultry manure + 200kg NPK is recommended for high shoot and root yields, as this proved to be a better option compared to single use of manure or inorganic fertilizer under Uyo (Obio Akpa) condition of southern Nigeria.

Conflict of interests

The authors declare that they have no conflicting interests.

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